

Chapter 1

Introduction



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A national monitoring network was mandated by the 1990 Clean Air Act Amendments (CAAA) to determine the effectiveness of promulgated emission reductions. The U.S. Environmental Protection Agency (EPA) established the Clean Air Status and Trends Network (CASTNet) to provide data for determining relationships between emissions, air quality, deposition, and ecological effects. CASTNet's objectives are to define the geographic distribution of pollutants and atmospheric deposition, detect and quantify trends in pollutants and deposition, and provide data on the dry deposition component of acid deposition and ground-level ozone concentrations. This report summarizes the CASTNet monitoring activities and the resulting concentration and deposition data for 2001.

Overview

CASTNet is the nation's primary source of atmospheric data on the dry deposition component of total acid deposition, rural ground-level ozone, and other forms of atmospheric pollution. CASTNet's origins stem from the CAAA, which mandated significant reductions in sulfur dioxide (SO₂) and nitrogen oxide (NO_x) emissions from electric generating plants. Congress recognized the need to track real-world environmental results as the emission reductions were implemented. As a result, the CAAA also formalized the establishment of a nationwide network for monitoring air quality and acid deposition. To meet this monitoring objective, the EPA established CASTNet, which has since evolved into a robust, national, long-term

monitoring program that measures changes in air quality and atmospheric deposition over broad geographic regions of the United States. The primary objectives for CASTNet are to:

- Monitor the status and trends in regional air quality and atmospheric deposition;
- Provide information on the dry deposition component of total acid deposition, ground-level ozone (O₃), and other forms of atmospheric gaseous and aerosol pollution; and
- Assess and report on geographic patterns and long-term, temporal trends in ambient air pollution and acid deposition.

CASTNet is the principal source of information on dry deposition throughout the United States. Dry deposition is a component of acidic deposition, which occurs when emissions of SO₂ and NO_x react with particles, water droplets, oxygen, and oxidants to form acidic compounds. Dry deposition represents a variety of meteorological, chemical, and biological processes that transport and deposit these acidic compounds to the environment. Wet deposition occurs when precipitation removes the acidic compounds from the atmosphere and deposits them to the environment. CASTNet provides information on trends in dry, wet, and total deposition of atmospheric sulfur and nitrogen species.

EPA and the National Park Service (NPS) sponsor CASTNet. CASTNet operates in partnership with other rural long-term monitoring networks such as the National Atmospheric Deposition Program / National Trends Network (NADP/NTN). Together these networks allow for a regional assessment of total (dry + wet) acid deposition throughout the United States. EPA relies on these long-term monitoring networks to generate the data and information used to assess the effectiveness of national air pollution control efforts under several different mandates, including Title IX of the CAAA, the National Acid Precipitation Assessment Program (NAPAP), the Government Performance and Results Act, and the United States - Canada Air Quality Agreement.

The principal component of CASTNet is the measurement of atmospheric sulfur and nitrogen pollutants and cations at rural sites across the United States. Nearly all CASTNet sites include continuous measurements of O₃ concentrations and meteorological conditions together with supporting information on vegetation and land use.

The meteorological, vegetation, and land use data are used as input to the Multi-Layer Model (MLM), a mathematical model that simulates atmospheric dry deposition processes (Meyers *et al.*, 1998; and Finkelstein *et al.*, 2000). The MLM is used to calculate deposition velocities (V_d), which are combined with the concentration measurements to estimate dry deposition of gaseous and aerosol pollutants. Vegetation data for 11 relatively recently installed sites were added to the MLM database during 2001.

Additionally, the network had included measurements of fine mass (PM_{2.5}) and its chemical constituents at some sites. These measurements were discontinued in 2001, and the CASTNet sampling systems were replaced by systems operated by the Interagency Monitoring of Protected Visual Environments (IMPROVE). IMPROVE currently performs aerosol monitoring at eight CASTNet sites.

Prior to CASTNet, EPA operated the National Dry Deposition Network (NDDN), which began operation in 1986. NDDN operated approximately 50 sites that became the core CASTNet sites when the NDDN was incorporated into CASTNet in 1991. NDDN also estimated dry deposition using measured air pollutant concentrations and modeled V_d .

NPS is responsible for the protection and enhancement of air quality related values in national parks and wilderness areas. Consequently, NPS established air quality monitoring stations as part of its air quality program. In 1994 NPS and EPA entered into a partnership agreement to operate CASTNet sites. As of the end of 2001, NPS sponsored 28 sites in CASTNet. NPS and EPA are responsible for operating their sites under a common set of quality assurance (QA) standards and similar monitoring and data validation

protocols. The measurements from the NPS sites are merged into a single database and delivered to EPA.

This report summarizes results of CASTNet measurements collected during 2001. Included in this report are annual and quarterly mean concentration data for atmospheric gaseous and particulate sulfur and nitrogen species and particulate cations with an analysis of trends in annual concentrations over the period 1990 through 2001; estimates of dry, wet, and total deposition and their trends over the 12-year period; O₃ data for 2001 and trends over the 12 years; concentrations of PM_{2.5} and its chemical constituents with time series analysis from 1994 through the end of sampling in 2001; and an assessment of data quality. CASTNet Annual Reports for 1998, 1999, and 2000 (Harding ESE, 1999, 2001a, and 2002a) can be found on the EPA web site: www.epa.gov/castnet/library.html.

Network Description

The locations of CASTNet sites, as of December 2001, are shown in Figure 1-1. Seventy-nine sites were operational. All sites were equipped with filter packs for measurement of pollutant concentrations and estimation of dry deposition. Seventy-seven sites measured O₃, although two solar-powered sites in New York and Vermont had only sporadic data capture and only during the ozone season. During July 2001, new CASTNet sites were installed at Indian River Lagoon, FL (IRL141) and Yukon Flats National Wildlife Refuge, AK – Poker Flats (POF425). The St. Johns River Water Management District (SJRWMD) sponsors IRL141, and NPS sponsors POF425. Collocated sampling systems were operated at three dry deposition sites for the purpose of estimating network precision. Appendix A provides the location and operational characteristics of each site by state, including information on start date, latitude, longitude,

elevation, and the types of measurements taken at each site.

In the beginning of 2001, collocated monitoring systems were operated at Mackville, KY (MCK131/231) and Ashland, ME (ASH135/235). In July, the collocated sampling was terminated at ASH135 and a new collocated site was established at Rocky Mountain National Park, CO (ROM206/ROM406). The two national park sites are operated independently. ROM206 is operated on behalf of EPA and ROM406 on behalf of NPS.

NADP/NTN operated wet deposition sampling systems at 15 EPA-sponsored and 28 NPS-sponsored CASTNet sites. This effort included analysis and reporting of precipitation chemistry samples. NADP/NTN also operated wet deposition sampling systems at other locations near virtually every CASTNet site. The NADP/NTN database represents the primary source of information on wet deposition across the United States. The combination of CASTNet and NADP/NTN data provides information on total (dry + wet) deposition. More information about NADP/NTN may be found on their web site:

<http://nadp.sws.uiuc.edu>.

CASTNet operated eight visibility sites beginning in 1993 and continuing into 2001. Seven sites were discontinued by May 2001, and the eighth site at Bondville, IL (BVL530) was discontinued at the end of 2001. CASTNet PM_{2.5} sampling systems were replaced by IMPROVE systems at the seven sites. CASTNet and IMPROVE sampling systems were collocated at BVL530 from March 2001 through the end of the year. Six of the eight sites were collocated with dry deposition sites, and two sites also measured optical properties of the atmosphere. Information about IMPROVE can be found on their web site:

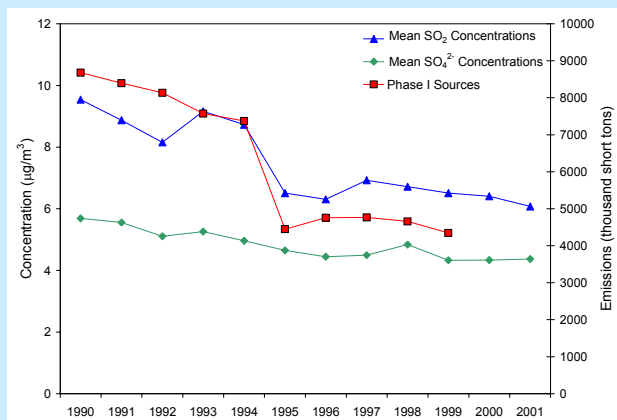
<http://vista.cira.colostate.edu/improve/>.

Figure 1-1. Map of CASTNet Sites as of December 2001



Note: Reference sites (★) used to perform trend analyses

SO₂ emissions and SO₂ and SO₄²⁻ concentrations have declined significantly over the period 1990 through 2001. SO₂ concentrations track almost identically with emissions from Phase I electric utility units. SO₄²⁻ concentrations also track closely.



Both EPA-sponsored sites and NPS-sponsored sites operate O₃ analyzers. CASTNet QA procedures for the EPA O₃ analyzers are different from the EPA requirements for State and Local Monitoring Stations (SLAMS) monitoring as described in 40 CFR Part 68, Appendix A (EPA, 1998). On the other hand, the QA procedures for the O₃ analyzers at NPS sites meet the SLAMS requirements. Consequently, not all the O₃ data can be used to gauge compliance with National Ambient Air Quality Standards (NAAQS) for ozone. The operation of two independent, collocated O₃ analyzers at ROM206/406 provides an opportunity to evaluate the precision of two systems with different QA and quality control (QC) procedures. Based on the CASTNet siting criteria, the O₃ measurements are generally considered regionally representative and, therefore, able to define geographic patterns of rural ozone across most of the United States. These data are appropriate for use in establishing general status and trend patterns in regional O₃ levels and for making general statements regarding the extent to which rural areas exceed the concentration levels mandated by the NAAQS.

One of the CASTNet sites is located in Egbert, Ontario, Canada (EGB181). At this site, day and night samples are collected weekly along with a standard weekly CASTNet filter pack. This system provides the means to compare results from CASTNet with the Canadian Air and Precipitation Monitoring Network (CAPMoN). CAPMoN collects daily filter samples. O₃ is not measured at Egbert.

Table 1-1 summarizes significant operational events and decisions for 2001. More details on the history of the network can be found in previous annual reports.

Table 1-1. 2001 Significant Operational Events

February
Direct data circuit between Gainesville and Jacksonville, FL offices became operational
Uninterruptible power supply installation was completed for all O ₃ analyzers
March
Discontinued aerosol sampling at SIK570, CDZ571, and LIV573. Replaced samplers with IMPROVE samplers
IMPROVE sampler installed at BVL530
April
Discontinued aerosol sampling at CTH510 and MKG513 and removed samplers
IMPROVE samplers installed at CTH510, MKG513, and ARE528
CASTNet server and database management system upgraded to Dell Poweredge™ 2400 and SQL Server™ 7.0 respectively
May
IMPROVE sampler installed at QAK572
Aerosol sampling discontinued, except at BVL530
June
Aerosol samplers removed at ARE528 and QAK572
July
IRL141 became operational
ROM206 (EPA sponsored) became operational
POF425 became operational
August
MLM was upgraded (Version 2.3)
September
Last AIRMoN samples received
October
Final calibration at ASH235; system removed
November
Quality Assurance Project Plan published
Independent systems audit of analytical and field calibration laboratories performed by Dr. C. Manos
Visibility aerosol database converted to local conditions
December
Aerosol sampling discontinued at BVL530

Methods

Methods employed by CASTNet were described in the 2000 Annual Report (Harding ESE, 2002a), the CASTNet Quality Assurance Project Plan (QAPP) (Harding ESE, 2002c), and previous annual reports. This information is not repeated herein. The 2000 Annual Report summarized information on field operations; laboratory operations; methods of data analysis, including discussion of the MLM, flux calculation and aggregation procedures, and reference sites used in the trend analyses; and the

CASTNet ambient measurements include:

- Sulfur dioxide (SO_2)
- Particulate sulfate (SO_4^{2-})
- Particulate nitrate (NO_3^-)
- Nitric acid (HNO_3)
- Particulate ammonium (NH_4^+)
- Particulate calcium (Ca^{2+})
- Particulate sodium (Na^+)
- Particulate magnesium (Mg^{2+})
- Particulate potassium (K^+)
- Ozone (O_3)
- Meteorological variables and information on land use and vegetation.

CASTNet database. The QAPP provides extensive information on CASTNet methods.

Reference Sites Used in Trend Analyses

One of the major goals of CASTNet is to monitor trends in air quality and deposition. The sites in Figure 1-1 depicted by a star indicate the locations of the 34 eastern sites used to perform trend analyses of pollutant concentrations measured during the period 1990 through 2001. The reference sites shown in Figure 1-1 were selected using criteria similar to those used by EPA in its National Air Pollutant and Emissions Trends Report (2000). Sites with complete data for at least 10 of the 12 years were selected. Missing quarterly data were

interpolated from adjacent quarterly data, e.g., first quarter 1996 data were interpolated from 1995 and 1997 first quarter data. Missing quarterly means for 1990 or 2001 were assumed equal to adjacent quarterly values. A valid quarterly mean was based on at least nine valid weeks (69%). Annual means were based on the four quarterly means for the year.

SO_2 and NO_x Emissions

Total annual SO_2 and NO_x emissions data by state were obtained from EPA for the period 1990 through 2000. In addition, SO_2 and NO_x emission data were obtained for Phase I and Phase II electric generating plants for 1990 through 2001. Title IV of the 1990 CAAA established the Acid Rain Program, which was designed to reduce emissions in two phases. Phase I ran from 1995 through 1999 and required substantive emission reductions from 435 large electric generating plants, involving approximately 2000 individual units (DOE, 1997). Phase II began in 2000 and includes more than 2000 generating stations. 2001 state total emissions data were not available from EPA prior to publication of this report. Consequently, maps of state total emissions for 2001 were not prepared. See the CASTNet 2000 Annual Report (Harding ESE, 2002a) for maps of 2000 SO_2 and NO_x emissions.

Figure 1-2 presents information on trends in SO_2 and NO_x emissions. The top two curves present data on total annual emissions for states east of and including the north-south line of states from Minnesota to Louisiana for the period from 1990 through 2000. In other words, each square/triangle represents the sum of emissions from the eastern states for that year. The bottom two curves represent emissions from Phase I and II generating stations over the period 1990 through 2001. The

sharp decline in SO₂ emissions in 1995 was produced by the reduction in Phase I emissions.

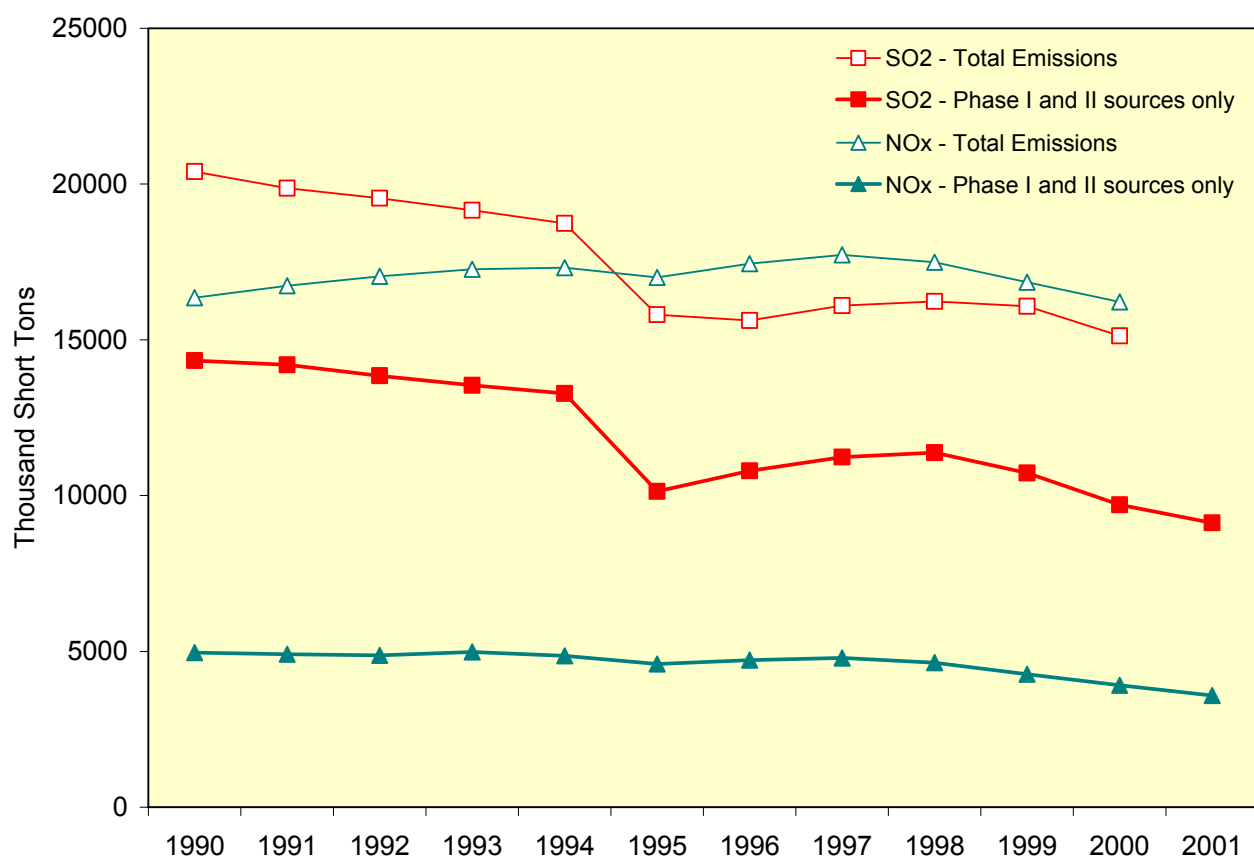
The SO₂ and NO_x data show an overall slow decline in emissions over the last four years.

Phase I and II utility SO₂ emissions by county for 2001 are presented in Figure 1-3. The utility emissions data were normalized by dividing the emission rate by the county area in square

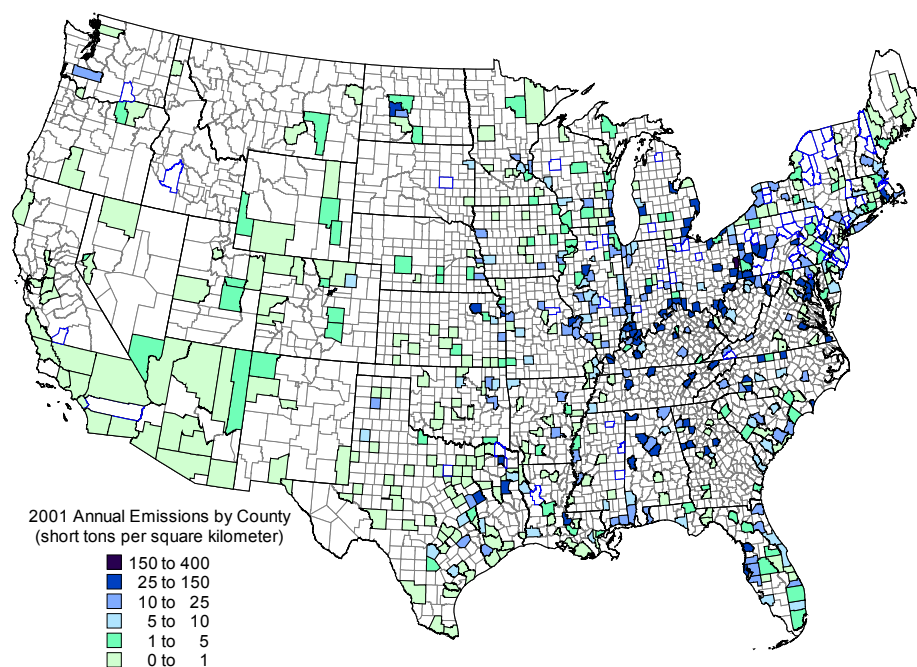
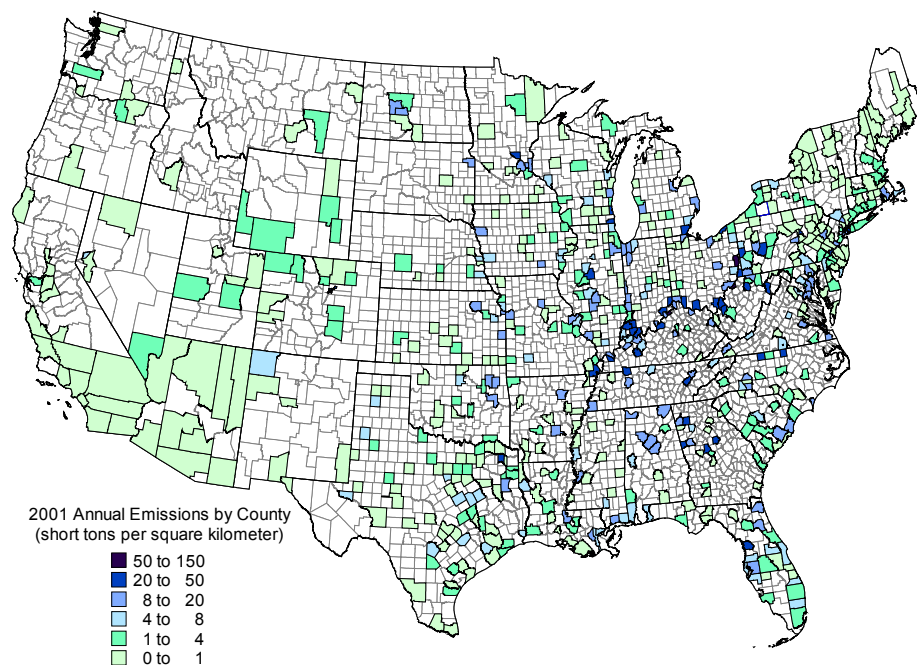
kilometers (km²). Several major sources are located in western Pennsylvania, Alabama, and along the Ohio River and other major bodies of water.

Combined Phase I and II area-weighted NO_x emissions by county are provided in Figure 1-4. Major utility sources are located along the Ohio River and in western Pennsylvania with additional individual large units scattered across the eastern United States.

Figure 1-2. Trends in SO₂ and NO_x Emissions for the Eastern United States



SO₂ emissions in the eastern United States declined sharply in 1995 as the result of mandated emission reductions at Phase I electric generating plants. Emissions have declined over the last three years as emission reductions are implemented at Phase II plants. NO_x emissions remained essentially constant over the 12-year period although a decline has been observed over the last three years.

Figure 1-3. Annual Utility SO₂ Emissions (Phase I and Phase II Plants, only) for 2001 by County**Figure 1-4.** Annual Utility NO_x Emissions (Phase I and Phase II Plants, only) for 2001 by County

Note: A county with no shading indicates no electric utility plant operates in that county or no data are available.